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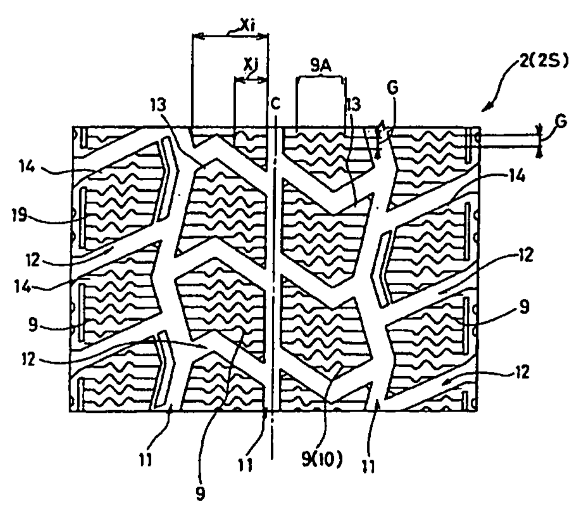
(54) **Studless tyre**

(57) A studless tyre comprises a tread portion (2) made of a vulcanised tread rubber compounded from 100 parts by weight of rubber component and 2 to 30 parts by weight of short fibres (F), the tread portion being provided in a ground contacting region with sipes (9), the sipes (9) being formed by pressing thin plates (24) into the tread rubber during vulcanising the tread rubber, whereby the thin plates (24) orient the short fibres (F) in a radial direction of the tyre.

Fig.2



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Description

[0001] The present invention relates to a pneumatic tyre, more particularly to a studless tyre improved in wet grip performance.
[0002] In recent years, studless tyres or winter tyres having no spikes or studs have come in to wide use.
[0003] In Japanese Patent No. 2637887, a rubber compound is disclosed which includes organic fibres and which is suitable as tread rubber for studless tyres, wherein, in order that the fibres are not oriented in a specific direction during extruding the raw compound, the organic fibres have a diameter of 0.1 to 0.3 mm and a length of 0.5 to 3 mm and the ratio of the diameter to the length is set in the range of from 0.06 to 0.6. Also the amount of the fibres is set in the range of from 5 to 20 parts by weight with respect to 100 parts by weight of material rubber compound. Therefore, in the tread portion of the finished tyre, the fibres are not oriented in a specific direction and the tyre tread rubber does not display directional characteristics.
[0004] In order to improve the wet grip performance, especially on an ice covered road, of the above-mentioned studless tyres, the present inventors studied and found that the road grip becomes a maximum when all the fibres are oriented in the tyre radial direction.
[0005] It is therefore an object of the present invention to provide a studless tyre in which the tread rubber in the ground contacting region contains short fibres oriented in the radial direction of the tyre.
[0006] According to the present invention, a studless tyre comprises a tread portion made of a vulcanised tread rubber compounded from 100 parts by weight of rubber component and 2 to 30 parts by weight of short fibres and the tread portion is provided in a ground contacting region with sipes the sipes being formed by pressing thin plates onto the tread rubber during vulcanising the tread rubber, whereby the thin plates orient the short fibres in a radial direction of the tyre.
[0007] Preferably, the short fibres have a diameter of not more than 30μm and a length of from 0.3 to 20 mm, and the thickness of the thin plates or the width of the sipes is in the range of from 0.2 to 0.5 mm. The spacings between the sipes are less than 10 mm.
[0008] Further, the short fibres are generally oriented in the circumferential direction of the tyre before pressing in the thin plates to form the tread, and the total length in millimetre of the axial component of all the sipes being in the range of from 0.05 to 0.15 times the area in square millimetre of the ground contacting region.
[0009] An embodiment of the present invention will now be described in detail in conjunction with the accompanying drawings:

Fig.1 is a cross sectional view of an embodiment of the present invention;
Fig.2 is a developed view showing the tread pattern thereof;
Fig.3 is a diagram for explaining a step of making a tread rubber strip;
Fig.4 is a cross sectional view for explaining a step of making the tyre; and
Fig.5 is a diagram for explaining how the short fibres are oriented by a plates.

[0010] In the drawings, a studless tyre 1 according to the present invention comprises a tread portion 2, a pair of sidewall portions 3, a pair of axially spaced bead portions 4 each with a bead core 5 therein, a carcass 6 extending between the bead portions, and a belt 7 disposed radially outside the carcass in the tread portion.
[0011] The carcass 6 comprises at least one ply of cords arranged at an angle of from 75 to 90 degrees with respect to the tyre equator C.
[0012] The belt 7 comprises at least two crossed plies of parallel cords laid at angle of from 10 to 30 degrees with respect to the tyre equator C. In this embodiment, the belt 7 is composed of two plies of high modulus cords such as steel cords.
[0013] The tread portion 2 is provided with tread grooves 10 to form a tread pattern such as a block pattern, rib-block pattern or the like including blocks 13, 14.
[0014] In this embodiment, the tread grooves 10 include a plurality of circumferential grooves 11 extending continuously in the tyre circumferential direction, and a plurality of axial grooves 12 intersecting the circumferential grooves 11. In Fig.2, the tread portion 2 is divided into blocks 13 and 14 in four circumferential rows, defining a block pattern.
[0015] Each of the blocks 13 and 14 is provided with a plurality of sipes 9 generally extending in the tyre axial direction.
[0016] In this example, most of the sipes 9 are zigzagged partially in the middle of the blocks in the tyre axial direction in order to increase the length of the sipes and to provide not only an axial component but also a circumferential component to improve wet grip performance in both the circumferential and axial directions of the tyre.
[0017] In Fig.2, both ends of each sipe 9 are opened to adjacent grooves. But, it is also possible to use a sipe of which one end is opened and the other end is closed, or a sipe both ends of which are closed, either solely or in combination.
[0018] The sipes 9 are arranged at substantially regular intervals G in the tyre circumferential direction.

[0019] The tread portion 2 is made of a tread rubber 15 containing 2 to 30 parts by weight, preferably not more than 20 parts by weight of short fibres F with respect to 100 parts by weight of the rubber component.

[0020] For the rubber component, various rubber-like elastic materials may be used. Usually, at least one kind of diene rubber selected from natural rubber (NR), isoprene rubber (IR), butadiene rubber (BR), styrene-butadiene rubber (SBR) and the like is used.

[0021] Further, various additives are blended, for example: vulcanising agent such as sulphur; coagent such as zinc oxide and stearic acid; accelerator such as thiazole accelerator, e.g. mercaptobenzothiazole (MBT) and dibenzothiazyl disulphide (MBTS) and sulfenamide accelerator, e.g. N-tert-ptyl-2-benzothiazyl sulfenamide (TBBS) and N-cyclohexyl-2-benzothiazyl sulfenamide (CBS); softener such as naphthenic oil, paraffinic oil and aromatic oil; reinforcing agent such as carbon black and silica; age resistor; wax; coupling agent; and the like.

[0022] The diameter of the short fibres F is not more than 30μm, preferably not more than 20μm, but not less than 5μm, preferably not less than 10μm.

[0023] The length of the short fibres F is not less than 0.3 mm, preferably not less than 0.4 mm, more preferably not less than 5 mm, but not more than 20 mm, preferably not more than 10 mm.

[0024] The tyre in this invention can be manufactured using a vulcanising mould as usual, and the tread portion 2 is formed by winding a strip 21 of raw tread rubber 15 around the carcass 6.

[0025] As explained above, the raw tread rubber 15 is compounded from the above-mentioned various materials which are mixed by a mixer such as Banbury mixer, rolls or the like.

[0026] The tread rubber strip 21 is formed by extruding or rolling the raw tread rubber 15 as shown in Fig.3. By rolling or extruding the raw rubber, the short fibres therein are oriented in the longitudinal direction of the strip. In Fig.3, calender rolls 20 are used. Thus, when the strip 21 is wound around the carcass 6, the short fibres are oriented in the circumferential direction of the tyre.

[0027] Next, to vulcanise the raw tyre 22, it is put into a mould 23 as shown in Fig.4. In this example, the mould 23 is a segmental mould comprising sectors 23T for moulding the tread portion 2. The sectors 23T are movable in the tyre radial direction towards the tyre, and the radially inside thereof is provided with thin plates 24 for forming the sipes. By moving the sectors 23T towards the tyre, the thin plates 24 are pressed into the surface of the raw tread rubber strip and inserted in the tread rubber. As a result, the sipes 9 are formed, and at the same time, the short fibres F are oriented as shown in Fig.5.

[0028] During inserting the plates 24, short fibres Fl therearound are caught by the radially inner edges 24E of the plates 24, and pulled toward the radially inside, and short fibres F2 positioned near the short fibres F1 are also drawn towards the radially inside. As a result, the short fibres near the sipes 9 are substantially oriented in the radial direction.

[0029] In order that the short fibres F are efficiently oriented, it is important that the length of the short fibres F is set in the range of from 0.3 to 20 mm, and the diameter thereof is set in the range of not more than 30μm. If the length of the short fibres F is less than 0.3 mm, the short fibres F are hard to be caught by the radially inner edges 24E, and thus it is difficult to orient them in the radial direction. If more than 20 mm, processing characteristics of the raw tread rubber become lowered, and rubber flow during vulcanising the tyre becomes worse, and the above-mentioned motion of the fibres F2 accompanying the pulled fibres F1 is hindered.

[0030] It is also necessary for efficiently orienting the short fibres F1 to set the thickness T of the plates 24 within the range of from 0.2 to 0.5 mm. If the thickness T exceeds 0.5 mm, it is difficult to orient the short fibres F. If the thickness T is less than 0.2 mm, the strength of the plates 24 is decreased, and it is difficult to make or maintain the tyre vulcanising mould 23.

[0031] By using such thin plates 24, it becomes possible to orient the short fibres existing within a range of about 5 mm from the plates or sipes.

[0032] Therefore, in order to orient almost all the fibres, the sipes are preferably arranged at intervals G of less than 10 mm (5 mmX2).

[0033] Further, it is preferable that the total length ΣXi (mm) of the axial components Xi of the respective sipes 9 is set in the range of from 0.05 to 0.15 times the gross area SS (mm^2) of the tread face 2S.

[0034] If the diameter of the short fibres F is more than 30μm, the short fibres F are hard to twine around the radially inner edges 24E, and thus it is difficult to orient the fibres in the radial direction. Further, the tread rubber 15 becomes hard and adhesion with the road surface decreases. If the diameter is less than 5μm, the fibres lose a minimum bending rigidity required for scratching the road surface.

[0035] If the amount of the short fibres F is less than 2 parts by weight, the road surface scratching effect becomes insufficient. If more than 30 parts by weight, the wear resistance of the tread rubber decreases.

[0036] If the ratio $\Sigma Xi/SS$ is less than 0.05, it becomes difficult to obtain a necessary on-the-ice performance. If more than 0.15, the tread rigidity is excessively decreased, and uneven wear resistance and manoeuvrability on dry roads decrease.

[0037] For the short fibres F, glass fibre, aluminium whiskers, organic fibres, e.g. polyester, nylon, vinylon, aromatic polyamide and the like can be used. But, for the dispersion during mixing, the prevention of softening or stiffening, and

the road surface scratching effect, inorganic materials having a specific gravity in the range of not less than 2.0, such as glass fibre and aluminium whiskers are preferably used. From the viewpoint of orientation, it is especially preferable that the length/diameter ratio of the short fibres F is not less than 30.

Comparison Tests:

[0038] Test tyres of size 185/65R14 (Rim size: 14X5.5JJ) having the tyre structure and tread pattern shown in Figs. 1 and 2 were made according to the specifications given in Table 1 and tested for on-the-ice performance, wear resistance, uneven wear resistance and manoeuvrability.

On-the-Ice Performance Test:

[0039] In the test, a test car, 2000cc FF passenger car, provided on all four wheels with the test tyres (Inner pressure: 200 Kpa) was run on an ice-covered road at a speed of 30 km/h, and sharp braking was carried out to obtain the braking distance and the average braking deceleration. The results are indicated by an index based on the reference tyre 1 being 100, wherein the larger the index, the better the performance.

Uneven Wear Resistance Test:

[0040] After the test car was run 5000 km on a dry asphalt road on a tyre test course, the difference in the amount of wear was evaluated around the sipes. The results are indicated by an index based on the reference tyre 1 being 100. The lager the index, the better the uneven wear resistance.

Manoeuvrability Test:

[0041] Running the passenger car on a dry asphalt paved 8-shaped course (25 meter radius), the lap time was measured. The results are indicated by an index based on the reference tyre 1 being 100. The large the index, the better the manoeuvrability.

Wear Resistance Test:

[0042] Using a Lambourn type wear tester, the wear resistance was measured under the following conditions:
Load: 2 kg, Slip rate: 30 %, Time: two minutes

[0043] The amount of wear is indicated by an index based on the Example tyre 1 being 100. The larger the index, the better the wear resistance.

Table 1

Tyre	Ex.	Ref.1	Ref.2	Ref.3	Ref.4	Ref.5	Ref.6	Ref.7
Tread rubber	B	A	B	B	C	D	E	F
ΣXi/SS	0.1	0.1	0.04	0.17	0.1	0.1	0.1	0.1
Ice performance	121	100	95	101	111	119	113	105
Uneven wear resistance	100	100	100	89	100	100	100	100
Wear resistance	100	-	-	-	102	80	98	102
Manoeuvrability	101	100	102	95	104	104	97	101

Table 2

parts by weight						
Rubber	A	B	C	D	E	F
Glass fibre Dia.(μm) Length (mm)	 -- --	 9 13	 9 25	 9 13	 35 15	 9 0.2

Table 2 (continued)

parts by weight						
Rubber	A	B	C	D	E	F
Rubber component						
NR	60	60	60	60	60	60
BR	40	40	40	40	40	40
Carbon black(N220)	30	30	30	30	30	30
Silica(VN3)	20	20	20	20	20	20
Paraffinic oil	15	15	15	15	15	15
Silane coupling agents (S169)	2	2	2	2	2	2
Paraffinic wax	2	2	2	2	2	2
Age resistor(6PPD)	2	2	2	2	2	2
Stearic acid	2	2	2	2	2	2
Hydrozincite	3	3	3	3	3	3
Sulphur	1.5	2	2	2	2	1.5
Accelerator(CZ)	1	1	1	1	1	1
Accelerator(DPG)	0.8	1	1	1	1	0.8

[0044] In the reference tyres 2 and 7, the short fibres were hardly oriented. In the reference tyre 3, the rigidity of the tread portion became insufficient. In the reference tyre 4, the degree of orientation becomes not good due to the decreased rubber flow. In the reference tyre 5, the wear resistance was greatly decreased due to too much short fibres. In the reference tyre 6, the orientation was not good and the tread rubber became too hard to provide a good adhesion to the road surface because the short fibres were too thick.

Claims

1. A studless tyre comprising a tread portion (2) made of a vulcanised tread rubber, the tread rubber being compounded from 100 parts by weight of rubber component and 2 to 30 parts by weight of short fibres (F) and provided in a ground contacting region with sipes (9), characterised in that the sipes (9) are formed by pressing thin plates (24) into the tread rubber during vulcanising the tread rubber, whereby the thin plates (24) orient the short fibres (F) in a radial direction of the tyre.

2. A studless tyre according to claim 1, characterised in that said short fibres (F) have a diameter of not more than 30μm and a length of from 0.3 to 20 mm, and said thin plates (24) have a thickness in the range of from 0.2 to 0.5 mm.

3. A studless tyre according to claim 1 or 2, characterised in that before pressing the thin plates (24), the short fibres (F) are generally oriented in the tyre circumferential direction, and the total length in millimetre of the axial components of all the sipes (9) being in the range of from 0.05 to 0.15 times the area in square millimetre of the ground contacting region.

4. A studless tyre according to claim 1, 2 or 3, characterised in that the spacings between the sipes (9) are less than 10 mm.

5. A studless tyre according to claim 1, 2, 3 or 4, characterised in that the tread portion is divided into blocks (13,14) each provided with a plurality of said sipes (9), and the sipes (9) include zigzag sipes having a zigzagged part in the middle of the length.

6. A method of manufacturing a studless tyre having a tread portion (2) including sipes (9) and having short fibres in the tread rubber compound, characterised by pressing thin plates (24) into the tread rubber to orientate short fibres in the tread and subsequently vulcanising it to tread rubber.

Fig.1

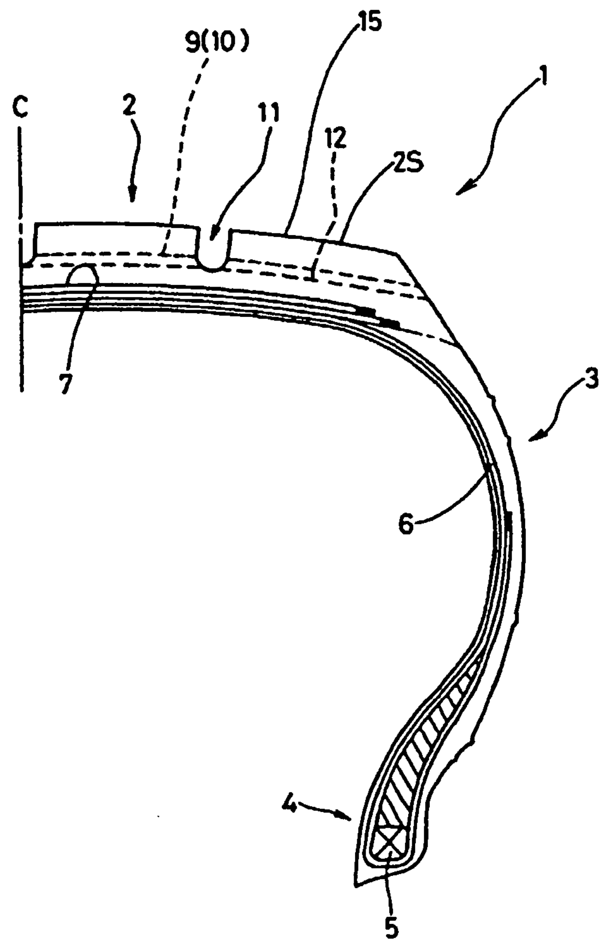

Fig.2

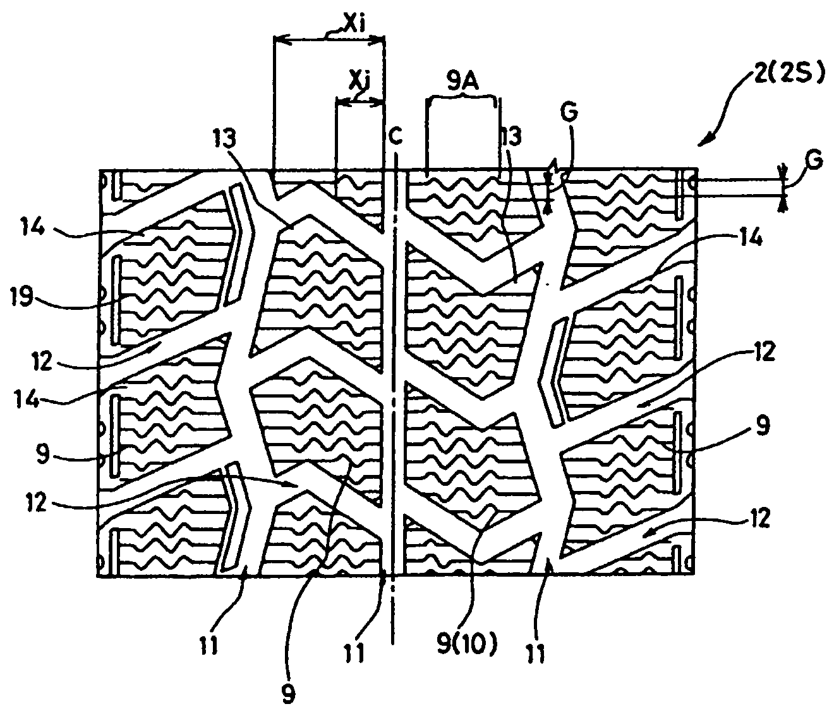

Fig.3

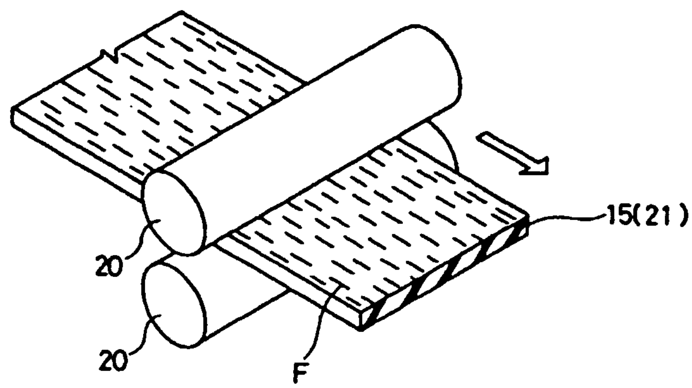

Fig.5

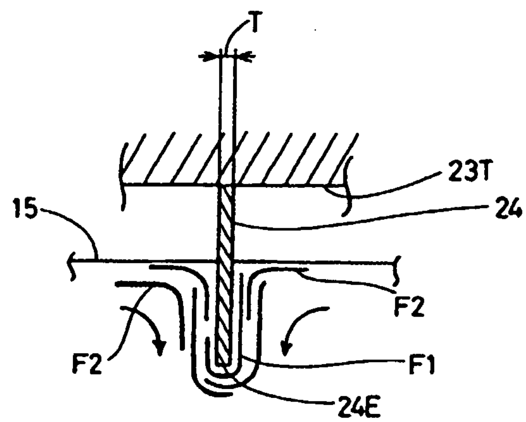

Fig.4